LUNAR PROSPECTOR 100TH DEGREE GRAVITY MODEL DEVELOPMENT. A. S. Konopliv and D. N. Yuan, Jet Propulsion Laboratory 301-125J, 4800 Oak Grove Drive, Pasadena, CA 91109 (ask@krait.jpl.nasa.gov).

Since its insertion into lunar orbit in January 1998 to December 1998, Lunar Prospector (LP) has provided Doppler gravity data from its polar nearly circular orbit with the altitude varying between 75 and 125 km. Prior to LP, all the low altitude data (<~ 200 km) from Lunar Orbiter (LO) in the 1960s and Apollo in the 1970s were for the nearside equatorial region (within 30° of the equator). Clementine, although polar, had a periapse altitude near 400 km. Thus LP has greatly improved the gravity in the high latitude areas, and, though less noticeable, LP has also improved the farside gravity and nearside equatorial gravity. The improved model [1] includes several new mascons on the nearside of the moon, partial resolution of mascons on the farside, and an improved polar moment of inertia. Several of the new mascons were for large impact basins with no visible maria fill.

The initial LP gravity solutions LP75D [2] and LP75G [1] are 75th degree and order spherical harmonic expansions of the gravity field with the latter a more complete solution that includes data up to April 12, 1998. However, it has been difficult to characterize the error in these models due to the gap in the farside gravity data and the effects of higher degree terms. With the help of the JPL/Caltech HP Exemplar supercomputer, a newer high resolution model to degree and order 100 (to be called LP100i and available for use prior to LPSC XXX) is currently under development that better characterizes the error in the gravity field and shows better resolution on the nearside of the moon. The farside mascons are still apparent but not as strongly probably due to leakage into the higher degree terms.

Because of the increased degree solutions and continued iteration, the constraint on the gravity field solution can be relaxed. The result, as shown in Fig. 1, is an error profile for the higher degrees that matches the observed power law (which is slightly less than the scaled Kaula power law for the Moon of $3.6\times10^{-4}/n^2$). The effects of terms beyond degree 100 are evident in the aliasing of the terms from about degree 90 to 100. So this gives a complete 90th degree gravity solution without aliasing to complement the 90th degree Clementine topography solution [3]. This preliminary LP100i solution includes, to date, all the LP Doppler and range data to Oct. 12, 1998.

The correlations of the gravity field with topography for the preliminary LP100i solution and the previous LP75G [1] are shown in Figure 2. Solving for a higher degree solution has increased the correlation with topography for the higher degrees. Both the LP75G and preliminary LP100i solution use a Kaula power law constraint on the coefficients. Previous model development for Venus and Mars have used a varying surface constraint (labeled as SAAP, Surface Acceleration A Priori, see [4]). Also being tested for the Lunar models is a Surface Moho A Priori (or SMAP), that is similar to SAAP except constrains, for a simple two--layer density model, the Moho variations on the farside to be comparable to the nearside for harmonic degrees roughly greater than 30. This smoothes the lunar farside gravity. If the models which use the topography as a constraint (i.e. SMAP) have possible use, they will be made available in addition to the Kaula power law and SAAP constraint solutions.

The nearside gravity of the Moon is known very well from LP and previous missions. However, the farside is only weakly known from the observed effect on the spacecraft orbit for various inclinations and eccentricities. Figure 3 shows to what harmonic degree the gravity field is known for the Moon's surface (or the degree strength, e.g. [4]). The resolution varies from degree 27 for the central farside to better than degree 90 for the nearside equatorial region where there is very low LO and Apollo data.

The uncertainty in the gravity acceleration at the surface (see Fig. 4) varies from 20 milligals for the nearside equatorial to 102 milligals for the higher latitude farside regions. The bimodal appearance of the farside error is do to the numerous LO and Apollo orbits between 10 and 30 degree inclinations that reduce the farside error for that latitude band to 80 milligals. The corresponding geoid uncertainties (see Fig. 5) range from 5 meters on the nearside to 30 meters for the farside.

On December 19, the LP orbit was lowered for one month to a near circular orbit with an altitude of 40 km to better determine the gravity field for extended mission operations. On January 16, 1999, the LP extended mission begins with a near circular obit at 30 km. This extended mission data will greatly improve the nearside resolution and will require solutions beyond degree 100 presented here.

References: [1] Konopliv A. S. et al. (1998) *Science, 281,* 1476-1480. [2] Konopliv A. S. et al. (1998) *Eos Trans. AGU Spring Mtg. Supp.* [3] Smith D. E. et al. (1997) *JGR 102*, 1591-1611. [4] Konopliv A. S. et al. (1999) *Icarus* (in press).

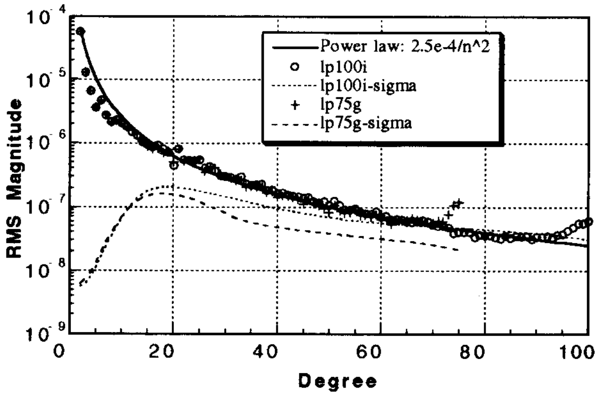

Figure 1. RMS Magnitude spectrum for previous lunar gravity solution LP75G [1] and the latest 100th degree and order model (LP100i) under development.

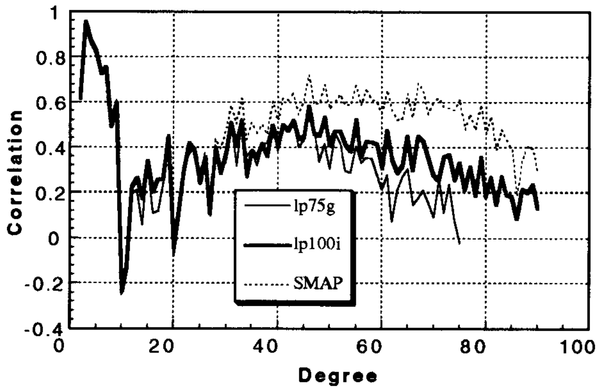

Figure 2. Correlation of lunar gravity fields with topography for the previous published solution (LP75G [1]), the 100th degree model with a Kaula power law a priori (LP100i) and a farside constraint on the Moho (SMAP).

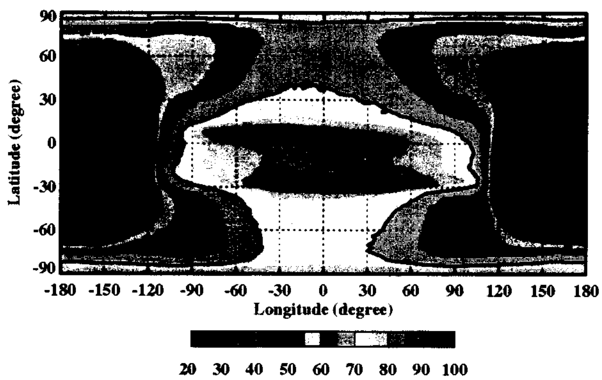

Figure 3. Resolution of the lunar gravity field LP100i in terms of the degree of the spherical harmonic expansion. Displayed is the degree strength - beyond this harmonic degree the uncertainty in the gravity field is greater than the expected signal. Black contour lines are shown every 10th harmonic degree.

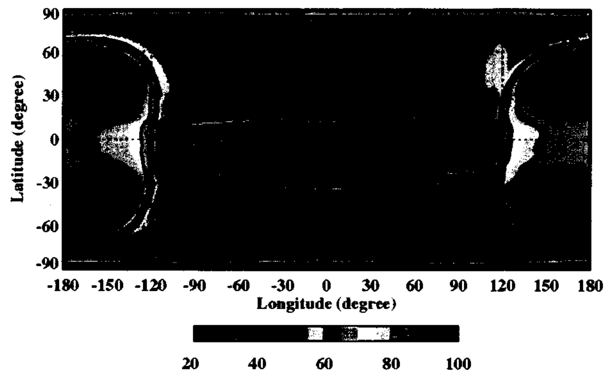

Figure 4. Radial acceleration error of LP100i mapped to the lunar reference sphere of 1738 km. Units are milligals and black contour lines are shown at 20 milligal intervals.

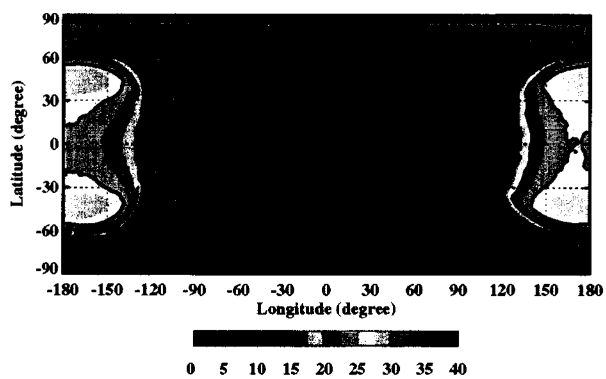

Figure 5. Geoid error of LP100i in meters and black contour lines are shown in 5 meter intervals.